Effect of advanced oxidation pre-treatment on membrane filtration parameters of dairy waste water

Zsuzsanna László, Szabolcs Kertész, Kristóf Szabó, Nándor Csorba, Ildikó Kovács and Cecilia Hodúr

University of Szeged, Department of Process Engineering, Moszkvai str.9, H-6725 Szeged, Hungary

The dairy industry is generally considered to be the largest source of food processing wastewater in many countries. The dairy industry generates wastewaters characterised by high biological and chemical oxygen demand representing their high organic content. The main contributors of dairy effluents are carbohydrates, proteins and fats originating from milk. Among available technologies for wastewater treatment, membrane technology, especially ultrafiltration (UF) of dairy wastewater yields a high permeate flux at low transmembrane pressure, but its permeate water is not reusable as it contains too much lactose [1, 2]. Advanced oxidation processes (AOPs) are widely used in the fields of water and wastewater treatments and are known for their capability to mineralise a wide range of organic compounds [3]. AOPs also have some other effects on the filtration procedure, e.g. the microflocculation effect of ozone may play a significant role in increased elimination efficiency, causing a decreased level of fouling and increased gel formation [4].

The aim of the present work was to compare the effect of ozone pre-treatment and the Fenton-reaction on the some dairy wastewater component, then to investigate the effect of pre-ozonation on the some filtration parameters, like permeate flux, fouling, and retention of pollutants, characterised by chemical oxygen demand.

Model solutions were prepared from milk powder. The ozone-containing gas was bubbled continuously through a batch reactor during the treatment. The ozone concentrations of the bubbling gas before and after the reactor were measured with a UV/VIS spectrophotometer at 254 nm. Ozone was produced from oxygen with a flow-type ozone-generator. The UF experiments were carried out in batch stirred ultrafiltration cell.

In the first series of experiments the degradation of some component of dairy wastewater, like lactose, casein, milk fat, whey and model dairy wastewater were investigated. It was found, that the pre-treatment by the AOPs decreased the chemical oxygen demand, and in the case of casein, whey and fat containing solutions the turbidity of the solutions also decreased. In the next series of experiments the untreated and pre-treated samples were ultrafiltered, and the fluxes were followed during the filtration procedure. It was found that flux with the pre-treatments decreases, due to arising degradation by-products. The retention of the turbidity and the COD values were compared after ultrafiltration of untreated and pre-treated samples. It was found that the Fenton-reaction has high elimination efficiency due to its simultaneous coagulation-flocculation and oxidation effects, but the ozone pre-treatment also enhanced the retention of pollutants.

The effect of both ozone and Fenton treatment on biodegradability of the compounds, and the concentrate of the membrane filtration were also investigated. The results indicate that in most cases the pre-treatments enhanced the biodegradability of the pollutants, allowing the further biological treatment of the concentrated pollutants.

Keywords: ozone; Fenton reaction; membrane filtration dairy waste water; biodegradability

Acknowledgements The authors are grateful for the financial support provided by the project TÁMOP-4.2.2/B-10/1-2010-0012. Project title: "Broadening the knowledge base and supporting the long term professional sustainability of the Research University Centre of Excellence at the University of Szeged by ensuring the rising generation of excellent scientists" and the Bolyai János Research Fellowship of the Hungarian Academy of Sciences.

References

[1] J. Luo, L. Ding, B. Qi, M.Y. Jaffrin, Y. Wana, A two-stage ultrafiltration and nanofiltration process for recycling dairy wastewater. Bioresource Technology 102. 7437–7442 (2011)

[2] A. Chollangi, M.M Hossain, Separation of proteins and lactose from dairy wastewater. Chemical Engineering Process 46. 398–404 (2007)

[3] G. Hodaifa, J.M. Ochando-Pulido, S. Rodriguez-Vives, A. Martinez-Ferez, Optimization of continuous reactor at pilot scale for olive-oil mill wastewater treatment by Fenton-like process. Chemical Engineering Journal 220. 117–124 (2013)

[4] Zs. László, Sz. Kertész, S. Beszédes, Zs. Hovorka-Horváth, G. Szabó, C. Hodúr, Effect of preozonation on the filterability of model dairy waste water in nanofiltration. Desalination 240. 170-177 (2009)

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